INSTRUCTION MANUAL FOR

EMHP

POWER SUPPLY

83-459-001 Revision C

LAMBDA EMI

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1 GENERAL INFORMATION

1.1 DESCRIPTION

This manual contains operation and maintenance instructions covering the Electronic Measurements, Inc. model EMHP series three-phase SCR controlled power supplies. These supplies are constant voltage/constant current, automated crossover sources of regulated DC power, packaged in fully enclosed steel and aluminum cabinets.

1.2 SPECIFICATIONS

The following specifications describe the published operational characteristics of this series of power supplies:

Package Sizes

Size 1 - Up to 20kW nominal output
Size 2 - Up to 30kW nominal output
Size 3 - Up to 60kW nominal output
Size 3 1/2 - Up to 90kW nominal output

1.2.1 AC INPUT:

460V ± 10% 60Hz standard, or optional voltage as specified.

1.2.2 REGULATION:

Voltage Mode - For line voltage variations or load current variations within the rating of the supply, the output voltage will not vary more than 0.1% of the maximum current rating.

Current Mode - For line voltage variations or load voltage variations within the rating of the supply, the output current will not vary more than 0.1% of the maximum current rating.

On those units in which the percentage of voltage or current ripple exceeds the specified regulation, the regulation will appear to be degraded due to the effect of this ripple on the measurement.

1.2.3 STABILITY:

The output voltage or current will remain within 0.05% for 8 hours after warm-up, with constant external effects.

1.2.4 RIPPLE:

Measured with either positive or negative output terminal grounded and 100% output voltage and current into a resistive load. (See rating sheet).

1.2.5 TRANSIENT RESPONSE:

Output variations, caused by line variations of ± 10%, and/or load variations between 50% and 100% of rated limits, will typically recover to within 1% of its final value within 200 ms.

1.2.6 TEMPERATURE COEFFICIENT:

Output voltage T.C. is 0.02% / °C of maximum rating.
Output current T.C. is 0.03% / °C of maximum rating.

1.2.7 OPERATING TEMPERATURE:

0 Degrees C to 50 Degrees C. Derate current linearly to 50% of table rating at 71 Degrees C ambient.

1.2.8 STORAGE TEMPERATURE:

-40 Degrees C to +85 Degrees C.

1.2.9 INSTRUMENTATION:

Voltmeter, ammeter, POWER ON Light, input phase indicator lights, and mode of operation indicator lights.

1.2.10 CONTROLS:

Circuit Breaker on-off control, START/STOP push button switches, VOLTAGE and CURRENT controls. A200 overvoltage protection adjustment on units equipped with OVP option.

1.2.11 COOLING:

All units are fan cooled and thermostatically protected. Air enters at the front of the unit and exits at the rear.

1.2.12 SIZE:

Excluding terminals:
SIZE 1 - 21 7/8" W X 30" H X 25 1/2" D (55.6 X 76.2 X 70.5 cm)
SIZE 2 - 27 1/8" W X 34 5/8" H X 25 1/2" D (69 X 88 X 74.3 cm)
SIZE 3 - 27 1/8" W X 44 1/2" H X 30 1/2" D (69 X 113 X 86.3 cm)
SIZE 3 1/2 - 27 1/8" W X 44 1/2" H X 36 1/2" D (69 X 113 X 92.7 cm)

For more detail see domensional outline drawing 02-459-002, 02-459-004, 02-459-003 and 02-459-009 in the back of this manual.

1.2.13 FINISH:

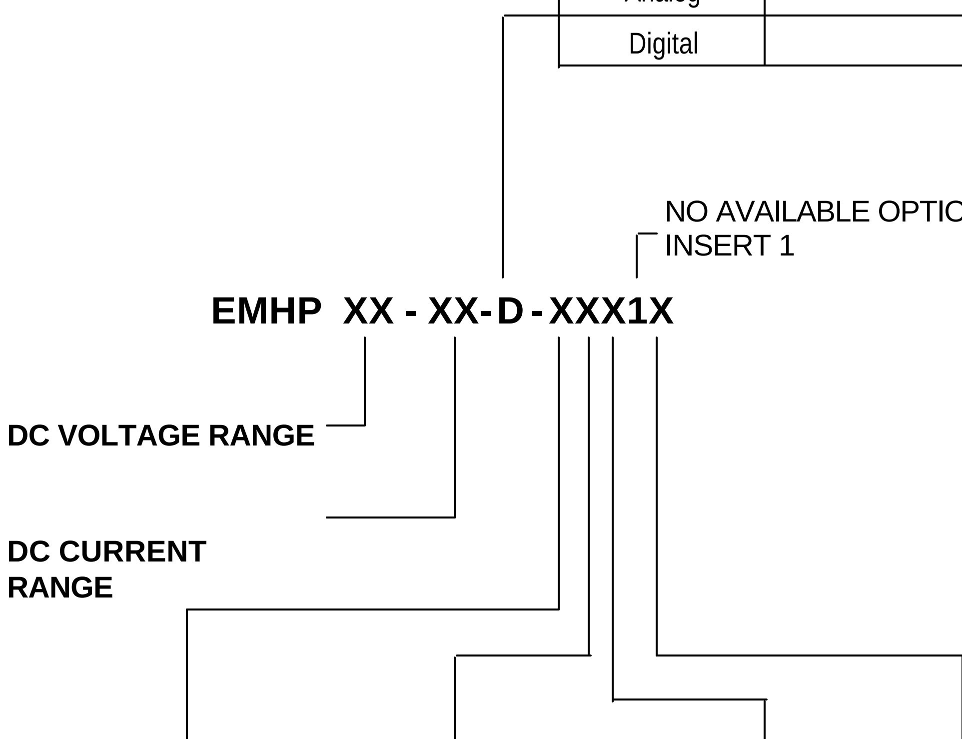
Front, rear and side panels are painted tan. Panel markings are silk-screened in black. Chassis frame and top cover are painted black. All other metallic parts are either plated or chemical film treated.

1.3 PART NUMBER DETERMINATION

The part number has 4 sections which determine the voltage output, the current capability and the options which go in a power supply. For example, the following model number is interpreted as follows:

EMHP 40-600-42212
EMHP = Type of power supply
40 = Voltage range
600 = Current range

PANEL METERS	
Analog	OMIT
Digital	D



AC INPUT			EXTERNAL MTG		OVP		REMOTE TURN ON	
1	187 - 243V	47-63Hz	1	BASE STD	1	WITHOUT	1	230VAC
2	342 - 418V	47-63Hz	2	CASTERS	2	WITH	2	115VAC
3	373 - 456V	47-63Hz	3	I-BEAM 4"			3	Not applicable
4	414 - 506V	57-63Hz	4	I-BEAM 6"			4	24VDC
5	216 - 264V	57-63Hz	This part number means that the style of power supply is an EMHP. Its maximum voltage range is 40 volts, its maximum current capability is 600 amperes, the AC voltage input is between 414 and 506 VAC. The unit also has Casters, an OVP Circuit and has the capability of 115 VAC Remote Turn-On.					
6	207 - 253V	47-63Hz						
7	396 - 484V	57-63Hz						
8	432 - 528/ 495 - 600V	57-63Hz						
9	356 - 434V	47-63Hz						
10	180 - 220V	47-63Hz						
11	360 - 440V	47-63Hz						

RATING CHART

MAXIMUM OUTPUT		RIPPLE INTO RESISTIVE LOAD		LOAD OR LINE REGULATION .1% OR AS BELOW, WHICHEVER IS GREATER	
VOLTAGE	CURRENT	VOLTAGE RIPPLE (mV RMS)	CURRENT RIPPLE (A RMS)		
10V	1000A 1500A 3000A	50	5 7.5 15	± .01V	± 1A ± 1.5A ± 3A
20V	750A 1000A 1500A	60	2.25 3.0 4.5	± .02V	± .75A ± 1A ± 1.5A
30V	600A 800A 1250A 3000A	70	1.4 2.0 3.0 7.0	± .03V	± .6A ± .8A ± 1.25A ± 3.0A
40V	450A 600A 1000A 2250A	80	.9 1.2 2.0 4.5	± .04V	± .450A ± .6A ± 1.0A ± 2.25A
60V	300A 500A 750A 1500A	100	.5 .8 1.3 2.5	± .06V	± .3A ± .5A ± .75A ± 1.5A
80V	250A 375A 600A 1125A	120	.4 .6 .9 1.69	± .08V	± .25A ± .375A ± .6A ± 1.125A
150V	130A 200A 350A 600A	180	.2 .25 .42 .72	± .15V	± .130A ± .20A ± .35A ± .6A
300V	60A 100A 200A 300A	300	.06 .10 .20 .30	± .3V	± .06A ± .1A ± .2A ± .3A
600V	30A 50A 100A	400	.02 .03 .07	± .6V	± .03A ± .05A ± .1A

2 INSTALLATION

2.1 UNPACKING

Carefully remove the top and sides of the packing crate and any bracing or padding material from the bottom, which also serves as a pallet. The power supply is attached to the crate bottom by four 3/8"-16 bolts. Casters (if so equipped) are packed separately with their mounting hardware.

2.2 VISUAL INSPECTION

Immediately inspect the power supply for any shipping damage. Verify the following:

a. Check the operation (knobs should rotate smoothly) of the front panel controls.
b. Verify that the circuit breaker latches in the ON and OFF positions.
c. Confirm that there are no dents or scratches on the panel surfaces.
d. Check front panel meters and LEDs for any broken or cracked glass.

If any damage is found, follow the "Claim for Damage in Shipment" instructions.

2.3 MECHANICAL

This power supply is intended for floor mounting, with or without casters or I-Beams. It can be fork lifted whether it is mounted on a pallet or not. If a pallet is not used, the fork lift blades must extend fully under the base so that both sides are supported. The power supply may be hoisted by substituting suitable lifting eye bolts (not supplied unless specified) for the four top cover bolts.

WARNING
Lifting force must be perpendicular to the top surface of the power supply. This may require the use of spreaders or a special sling arrangement.

Make sure that adjacent equipment does not block air intake or exhaust openings. Except for test purposes, this power supply should not be operated with covers removed.

2.4 ELECTRICAL

This power supply requires a three-phase input of the specified voltage and frequency, with nominal voltage line-to-line (three-wire system). Phase rotation sequence need not be observed when connecting the power line to input terminals of the power supply. No neutral connection is required, but for safety, the chassis ground terminal marked GRD should be connected to earth ground. A branch circuit disconnecting switch or plug having a suitable interrupting rating should be installed in the power line to this power supply in accordance with electrical code requirements. For input wire size, see a wire table.

NOTE: The input wires should be oversized so as to provide as low an impedance as practical, since high peak currents are drawn. Input wires are inserted through the conduit opening in the rear of the enclosure. Access to the input wiring terminals is made by removing the cover plate adjacent to the conduit opening. These terminals are of the pressure connector type. Connect the load to the POS and NEG output terminals using heavy enough leads to prevent substantial IR drops between the output terminals and the load. Remote sensing can be used to compensate for IR drops. See paragraph 3.3.2.

NOTE: Both output terminals are floating and either may be grounded or operated at any voltage less than 600V with respect to chassis ground.

3 OPERATING INSTRUCTIONS

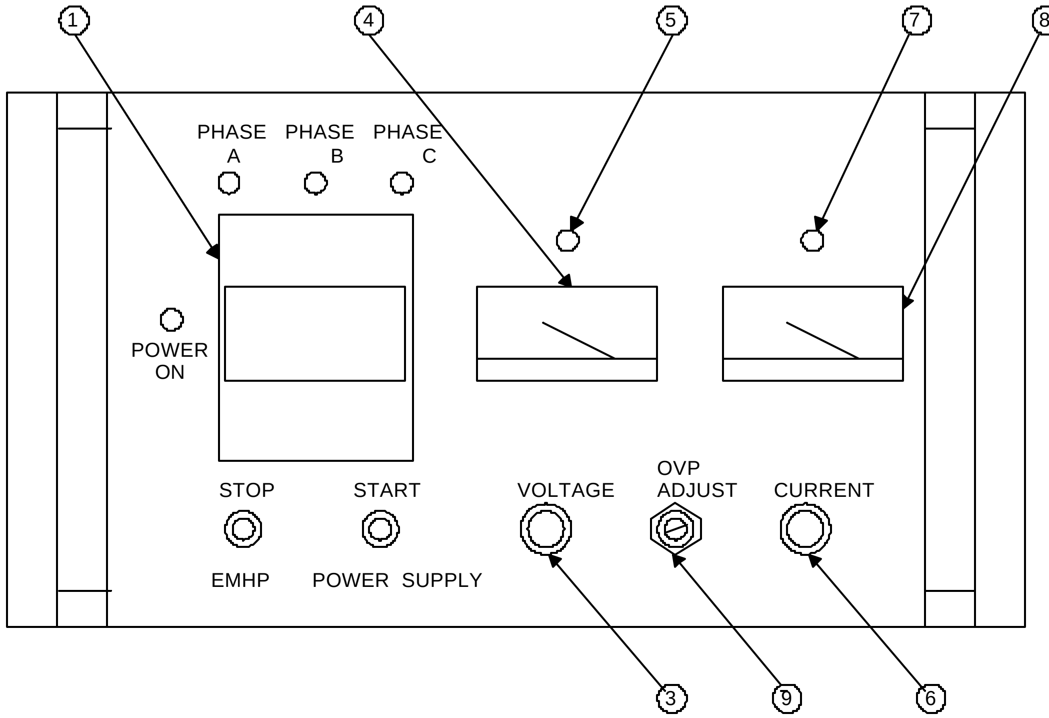


Figure A: Front Panel Controls and Indicators

3.1 CONTROLS AND INDICATORS

The front panel surface contains all the controls and indicators necessary to operate the supply in its normal mode. The following checkout procedure describes the use of the front panel control and indicators (Figure 1, Section 3.3.1) and ensures that the supply is operational. This preliminary check of the power supply is done without a load connected.

a. Check the barrier jumper straps on the back of the unit, as shown in Figure 1, for normal mode.

b. Set all controls completely counterclockwise.

c. Turn the CIRCUIT BREAKER (1) on/off switch to "on". The fans will start immediately. Push the Start Button after a 10-15 second delay due to the soft start circuit output will occur.

d. All 3 Phase Indicators must be lit.

e. Advance CURRENT CONTROL (6) one-half turn and slowly advance VOLTAGE CONTROL (3). The DC VOLTMETER (4) will deflect from zero to maximum rating of the supply as this control is advanced completely clockwise. The VOLTAGE INDICATOR (5) will be lit.

f. Return all controls completely counterclockwise.

g. To check out constant current, first turn-off supply. Connect a shorting bar across the plus and minus output terminal at the back of the power supply.

h. Push the Start Button. Advance the VOLTAGE CONTROL (3) one turn clockwise and slowly advance the CURRENT CONTROL (6). The DC AMMETER (8) will deflect smoothly from zero to the rated current of the supply as this control is advanced clockwise. The CURRENT INDICATOR (7) will be lit.

i. Return all controls completely counterclockwise and turn unit off. Disconnect output shorting bar.

3.1.1 OVP OPERATION

If supply is equipped with an overvoltage crowbar, the front panel will contain OVERVOLTAGE ADJUSTMENT (9). This potentiometer may be adjusted through an access hole in the front panel.

NOTE: All overvoltage circuitry has been properly adjusted to their respective unit before leaving the factory.

For trip levels less than the maximum output voltage or to check the overvoltage circuitry simply:

A. Set the potentiometer fully clockwise

B. Adjust the power supply output voltage to the desired trip level.

C. Slowly adjust the potentiometer counterclockwise until OVP trips turning off the set.

Once fired, the SCRs remain on until the anode voltage is removed (decreased below its "on" level) or until anode current falls below a minimum "holding" current. The overvoltage range is from 50% to 100% of the maximum output voltage of the unit.

If any of the above events does not occur, the supply is defective and must not be operated. Depending on circumstances either warranty service or troubleshooting as described elsewhere in this manual is required.

3.2 GENERAL OPERATION

The voltage and current controls (local and remote) set the boundary limits for the output voltage and current respectively. The relationship of load resistance to control settings determines whether the power supply is operating in constant voltage or constant current mode. Automatic crossover between modes occurs at the following load resistance value:

$$\text{Load resistance (Ohms)} = \frac{\textit{Voltage Control Setting (volts)}}{\textit{Current Control Setting (amperes)}}$$

At higher load resistance, the power supply operates in the constant-voltage mode and at lower resistance in the constant-current mode.

3.3 MODES OF OPERATION

This power supply is designed so that its mode of operation is selected by making strapping connections between terminals on terminal strip TB3 which is bolted to the rear panel of the power supply. The terminal designations are silk-screened on the rear panel of the power supply. (Refer to the following chart).

TB3-PIN	PIN DESCRIPTION
1	+ Voltage (+V)
2	+ Voltage Remote (+V REM)
3	Voltage Programming Current (V PROG I)
4	Voltage Amplifier (V AMP IN)
5	Voltage Programming Resistor (V PROG R)
6	Voltage Programming Resistor Common (V PROG R COM)
7	- Voltage Remote (-V REM)
8	- Voltage (-V)
9	Current Programming Current (I PROG I)
10	Current Amplifier (I AMP IN)
11	Current Programming Resistor (I PROG R)
12	-Shunt (-I)
13	Inverted Amplifier (INV AMP IN)
14	+ Shunt (+I)

3.3.1 NORMAL OPERATION (FIGURE 1)

When shipped from the factory, each supply is configured for constant/voltage, constant/current, local programming, local sensing, single unit mode of operation. This normal mode of operation is usually used in most applications. All performance specifications unless otherwise stated are defined in this configuration. Ripple, programming speed, transient response and stability are optimized with the supply so configured.

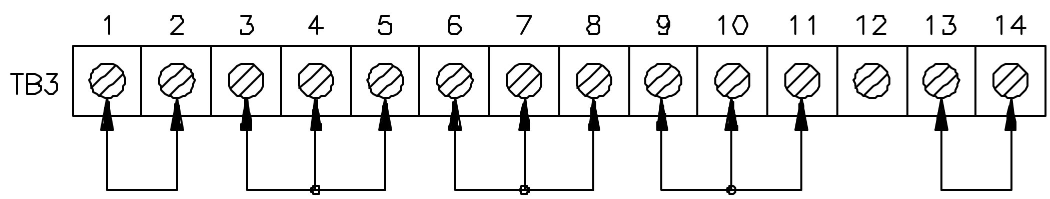


Figure 1 Normal Operation Configuration

Connecting Load

Each load must be connected to the power supply output terminals using separate pairs of connecting wires. This will minimize mutual coupling effects between loads and will retain full advantage of the low output impedance of the power supply. Each pair of connecting wires must be as short as possible and twisted or shielded if strong AC or RF fields are present to reduce noise pickup. (If a shielded pair is used, connect one end of the shield to ground at the power supply and leave the other end disconnected.)

3.3.2 REMOTE SENSING (FIGURE 2)

In applications where the effect of the voltage drop (IR) of the DC load wires would adversely affect the performance of the load it is possible to sense the voltage at the load instead of the output terminals. Remote sensing will therefore remove the effect of changes in load current through the power distribution system. The maximum available load voltage then equals the rated power supply output voltage less the total of the IR drop.

Connections for Remote Sensing

1. Remove jumpers between the following terminals:
   TB3-1 and 2
   TB3-7 and 8
2. Connect the positive point of load to TB3-2.
3. Connect the negative side of the load to TB3-7 and 6.
4. If the leads to the load are approximately 5 feet or more it may be necessary to connect a capacitor across the load; or capacitors between TB3-1 and TB3-2 plus TB3-7 and TB3-8. Within the range of 100-1000mfd.

   To protect the system from open sense leads, a 100Ω ½ Watt 5% resistor should be installed between TB3-1 & 2 and TB3-7 & 8.

   Because each application can be different consult factory if problems occur.

NOTE: Since the voltmeter is internally connected to the sensing terminals, it will automatically indicate the voltage at the load, not the power supply output terminal voltage.

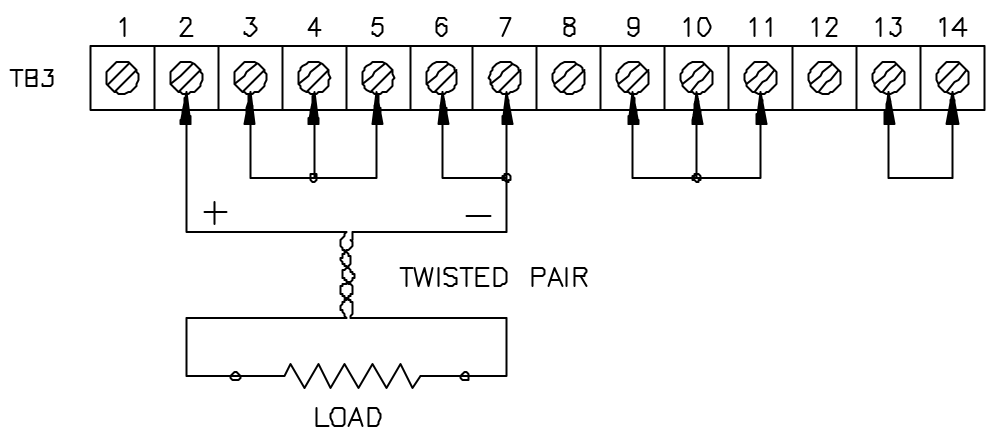


Figure 2 Remote Sense Configuration

3.3.3 REMOTE PROGRAMMING

This power supply may be operated in a remotely programmed mode (externally controlled) by the use of an external resistance. The wires connecting the programming terminals of the supply to the remote programming device should be twisted or if strong AC or RF fields are present, shielded.

Caution: If the remote programming function fails or is inadvertently adjusted so that the output voltage is programmed to levels of greater than 15% above ratings, damage to the output filter capacitors may occur. To protect against this, it is suggested that the overvoltage protection option be used to limit the maximum voltage excursion and safely shut the power supply down.

<u>Remote Programming by External Resistance</u>

Voltage Channel (Figure 3)

A resistance of 0 to 5000 Ohms programs the output from zero to full rated voltage.

Prog (Ohms) = 5000 x Desired Voltage/Full Rated Output Voltage

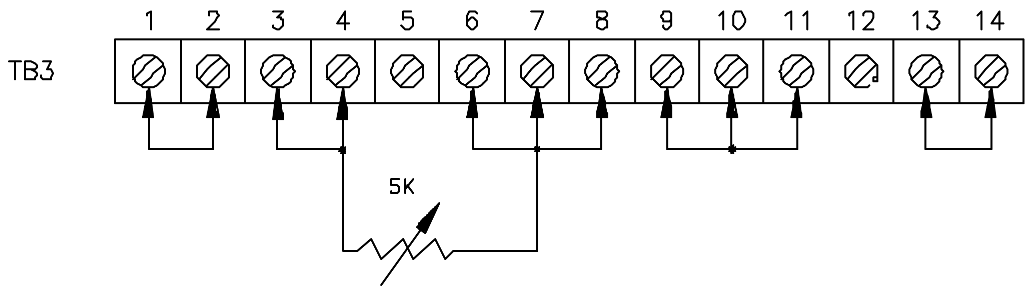


Figure 3

1. Remove the jumper between terminals TB3-5 and 4.
2. Connect the programming resistance between terminals TB3-4 & 3 and TB3-7.

Current Channel (Figure 4)

A resistance of 0 to 100 Ohms programs from zero to full rated current.

Prog (Ohms) = 100 x Desired Current/Full Rated Current

1. Remove the jumper between terminals TB3-10 and 11.
2. Connect the programming resistance between terminals TB3-9, 10 and 12.

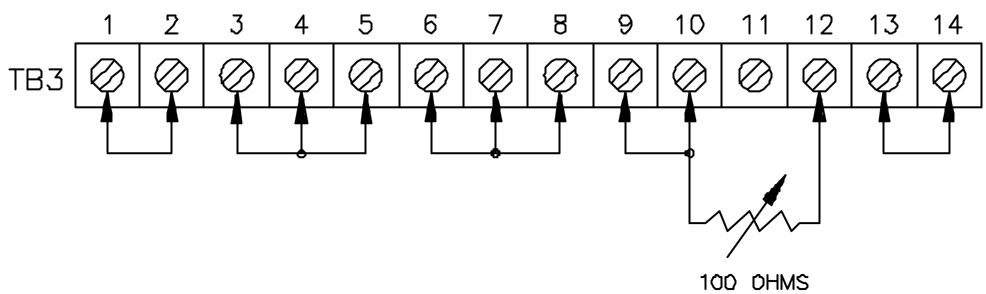


Figure 4

CAUTION: An opening in the remote programming circuit is effectively a high programming resistance and will cause an uncontrolled voltage or current rise to the maximum output of the power supply. This may cause possible damage to the power supply and/or the load. For this reason, any programming resistor switches must have shorting contacts. This type of shorting switch connects each successive position before disconnecting the preceding one.

Remote Programming by External Voltage

The front panel voltage or current control is disabled in this operating mode.

Voltage Channel (Voltage Program), (Figure 5)

A voltage of 0 to 5V programs the output from zero to full rated voltage.

1. Remove the jumpers between terminals TB3-3, 4 and 5.
2. Connect the programming voltage source between TB3-4 (pos) and TB3-7 (neg.).

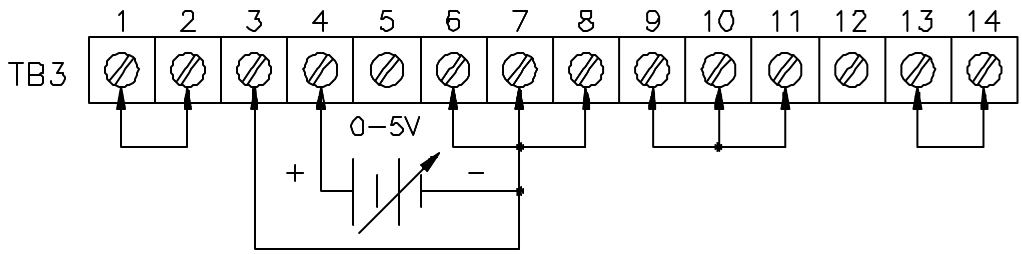


Figure 5

Current Channel (Voltage Program), (Figure 6)

A voltage of 0 to 100 Millivolts programs the output from zero to full rated current.

NOTE: A signal from a higher potential source may be attenuated to this 100mv level by a resistor divider. For best performance, the source impedance of this divider must not exceed 1000 Ohms.

1. Remove the jumpers between terminals TB3-9, 10 and 11.
2. Connect the programming voltage source between terminal TB3-10 (pos.) and TB3-12 (neg.).

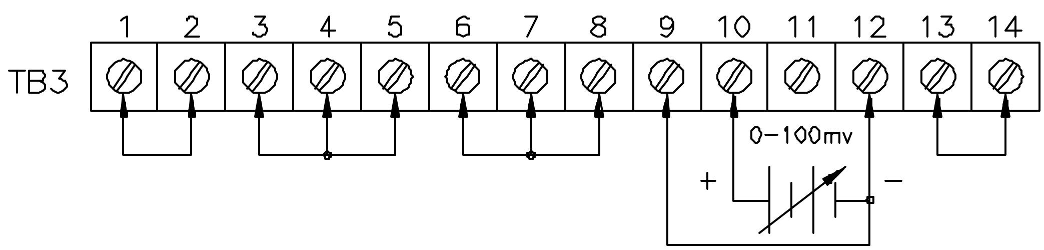


Figure 6

Remote Programming by External Current

The front panel voltage or current control is not disabled in this programming mode. The front panel control must be left in the clockwise position to maintain the programming constant or signal to the output.

A current of 0-1 mA programs the output from zero voltage to full rated voltage or current.

Current Program of Voltage Channel (Figure 7)

1. Remove the jumpers between terminals TB3-3 and 4.
2. Connect the programming current source between terminals TB3-4 (pos.) and TB3-7 (neg.).

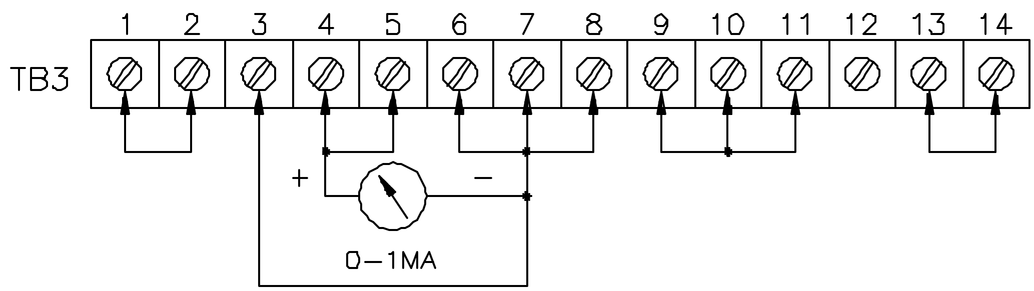


Figure 7

Current Program of Current Channel (Figure 8)

1. Remove the jumper between terminals TB3-9 and 10.
2. Connect the programming current source between TB3-12 (neg.) and TB3-10, 11 (pos.).

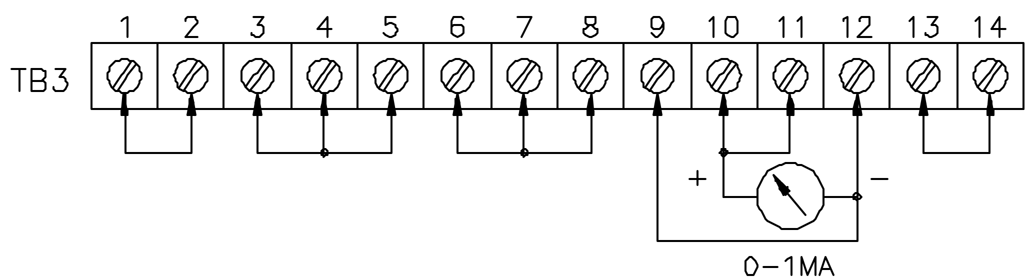


Figure 8

3.3.4 PARALLEL OPERATION

NOTE: It is not recommended to operate more than three EMHP power supplies in parallel without thorough evaluation by the user with counseling from the Engineering Department of Electronic Measurements, Inc.. This will help avoid any failures in the application because of instability of the power supplies.

The simplest parallel connection is that of attaching the positive and negative terminals to their respective load points.

The procedure is as follows:

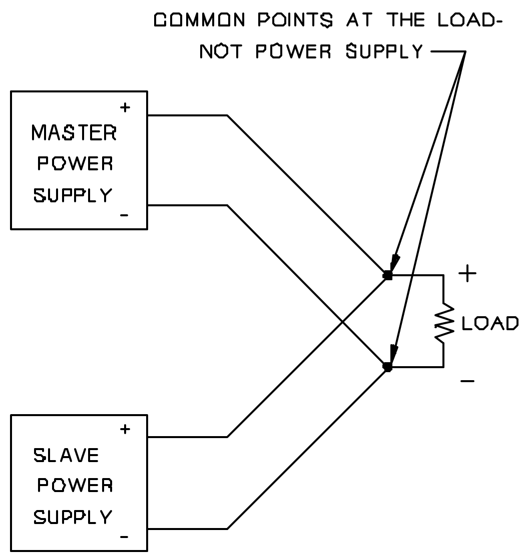
1. Turn on all units (open circuit) and adjust to appropriate output voltage.
2. Turn supplies off and connect all positive output terminals to the positive side of the load and all negative output terminals to the negative side of the load.

NOTE: Individual leads connecting unit to the load must be of equal lengths and oversized to provide as low an impedance as practical.

3. Set the current controls clockwise.

4. Turn units on one at a time, until the sum of the power supply current capabilities exceeds the load current drawn.
5. Using the voltage controls balance each unit voltage for equal output current.
6. Set the current controls to limit just above running current so that if a unit's output voltage drifts upward, it will become current limited rather than carry an excessive share of load current.

IMPORTANT: When the units contain the overvoltage option do not connect them in parallel without consulting the Engineering Staff of Electronic Measurements. Irreparable damage will occur if one of the paralleled units goes into overvoltage without proper paralleling of the OVP option.



Parallel Operation-Master/Slave (Figure 9)

In this configuration, the power supply designated the master is used to control the voltage and current operation of all other supplies, referred to as slaves.

1. Disconnect the following jumpers of all slaves:
   TB3-13 and 14
   TB3-9, 10 and 11
2. Connect a jumper between TB3-10 and 12 of all slaves.
3. Connect the master supply TB3-12 and TB3-13 of each supply as shown in either Figure 9A or 9B.
4. Adjust the voltage control of each slave to maximum CW.
5. See Figure 9A or 9B for + and - voltage connection.
6. Turn each slave on and then the master.
7. Adjust the master for required output voltage or current. The output leads from each power supply must be of equal resistance to a point of load near the supply to assure equal sharing.

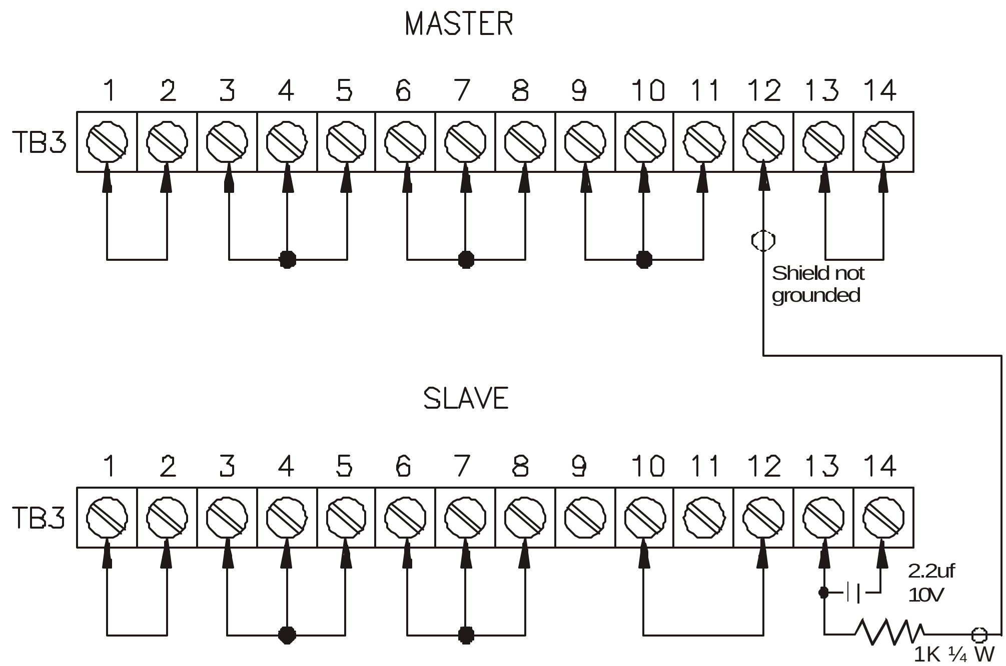


Figure 9A

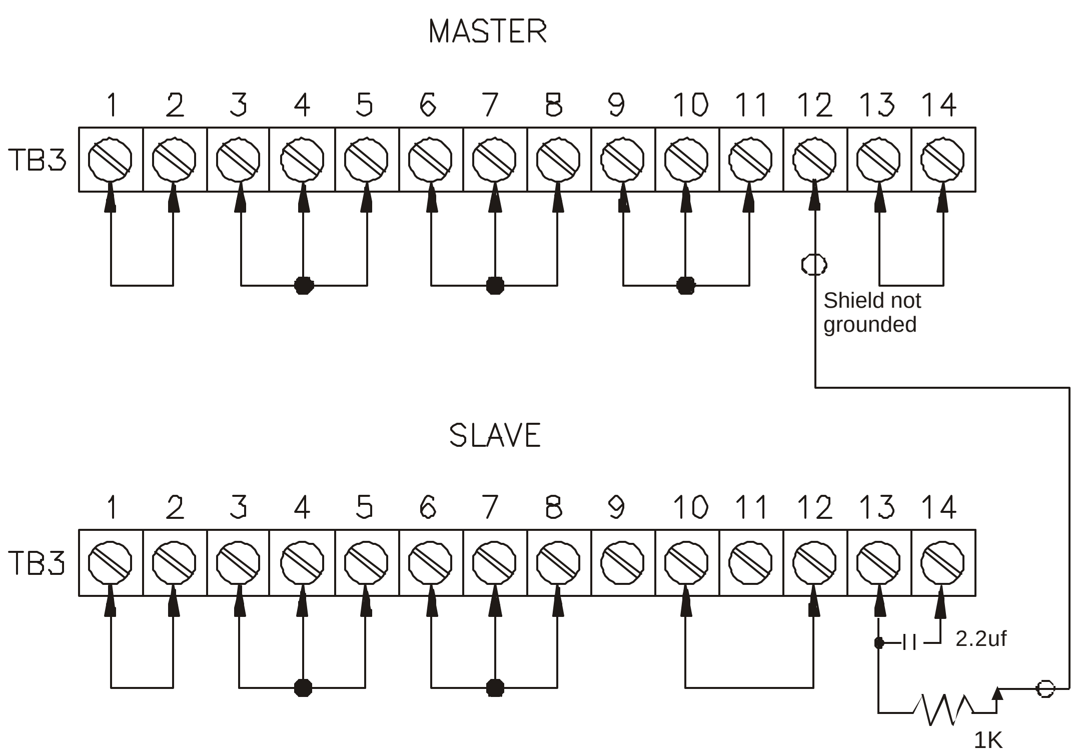
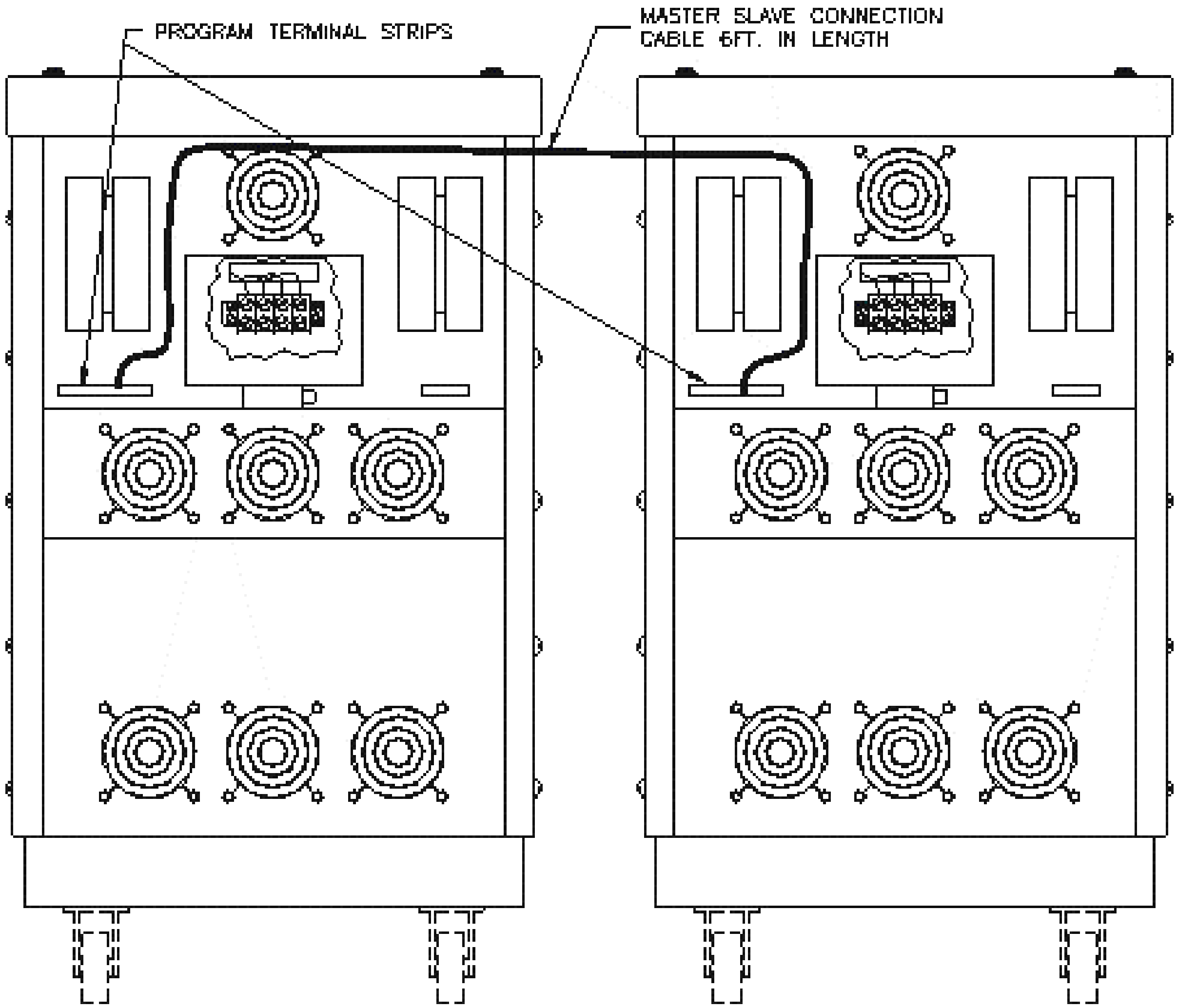
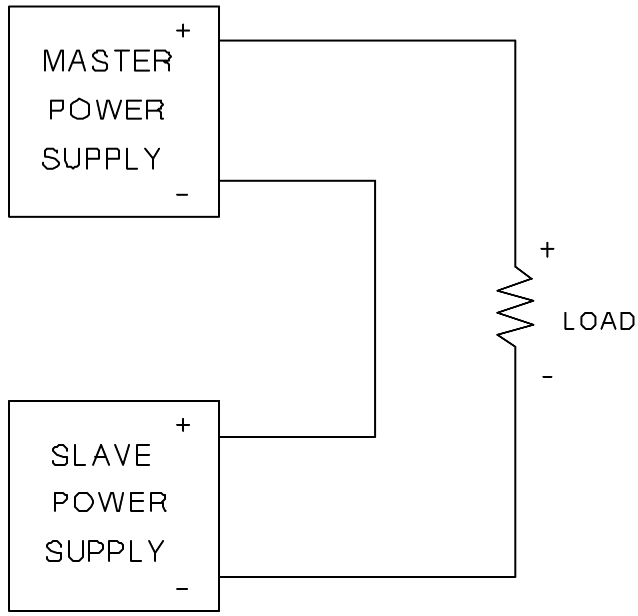


Figure 9B


PROGRAM TERMINAL STRIPS
MASTER SLAVE CONNECTION
CABLE 6FT. IN LENGTH

3.3.5 SERIES OPERATION

Two EMHP power supplies can be operated in series simply by connecting the negative output terminal of one unit to the positive output terminal of the other. The adjustment of each unit functions independently and the total output voltage is the sum of each unit output voltage. NOTE: The voltage at any output terminal must never exceed 600V with respect to chassis ground. Consult Electronic Measurements, Inc. Engineering Department for series operation of more than two supplies.



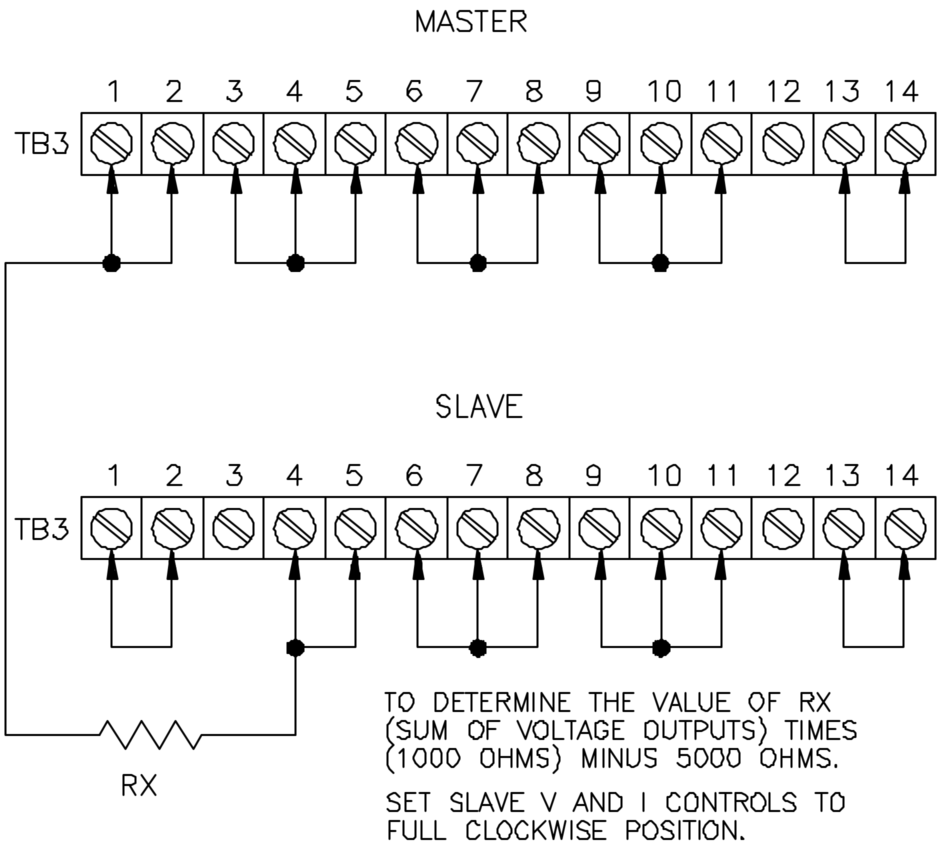


Figure 10

3.3.6 REMOTE METERS

A remote voltmeter may be connected between terminals TB3-2 (pos.) and TB3-7 (neg.). If remote sensing is also being used, the remote voltmeter will indicate the voltage at the load. To indicate the voltage at the power supply output terminals connect the remote voltmeter between terminals TB3-1 (pos.) and TB3-8 (neg.).

A remote millivoltmeter may be connected between terminals TB3-12 (neg.) and TB3-14 (pos.). A voltage of 0 to 100mv across these terminals indicates output current from zero to full rating unless otherwise specified (see main schematic). To compensate for voltage drops in long remote ammeter leads a meter movement having a full-scale sensitivity of the less than 100mv is used in series with a calibrating resistor.

The leads to the remote meters should be twisted, and if strong AC or RF fields are present, the leads should be shielded. One end of the shield should be grounded to terminal TB3-14 and the other end left floating.

3.3.7 REMOTE TURN-ON

External Voltage Source

1. Connect either an external 12-24 DC voltage supply or a 12-24 VAC voltage supply to terminals 1 and 2 on TB4. The link between terminals 2 and 3 must be removed. NOTE: Terminals are polarity sensitive to DC. Terminal 1 (plus) and Terminal 2 (negative).

Dry Contact

1. Connect an n/o voltage switch or contactor between terminals 2 and 3 of TB4.

3.4 REMOTE START/STOP OPERATION (NOT AVAILABLE WITH 24V REMOTE TURN-ON OPTION)

The start/stop function may be controlled from a remote location by means of either two wire control (single-pole, single-throw, maintenance contact switch) or three wire control (normally open "start" push button switch and normally closed "stop" push button switch). Relay coil operating voltage can be supplied internally from the power supply itself, or externally from a remote source. (See main schematic diagram for coil voltage rating of power relay K1).

NOTE: With remote three wire control, the front panel START and STOP buttons still function as local controls. With remote two wire control, the front panel START and STOP buttons are disabled.

CAUTION

Two wire control should not be used on units equipped with the overvoltage protection option, since in the event the OVP trips, the power relay K1 will open and close repeatedly, probably causing damage to the OVP and other components.

3.4.1 THREE-WIRE CONTROL, INTERNAL SOURCE

Remove the jumper between terminals TB2-1 and 2. connect the "Stop" switch (normally closed) between terminals TB2-1 and 2 and the "Start" switch (normally open) between terminals TB2-2 and 3.

3.4.2 THREE-WIRE CONTROL, EXTERNAL SOURCE

Remove the jumpers between terminals TB2-1 and 2 and between terminals TB2-4 and 5. Connect the "Start" switch between terminals TB2-2 and 3. Connect the "Stop" switch between terminals TB2-2 and one side of the external source. Connect the other side of external source to terminal TB2-4.

3.4.3 TWO-WIRE CONTROL, INTERNAL SOURCE

Remove the jumper between terminals TB2-1 and 2. Connect the switch between terminals TB2-1 and 3.

3.4.4 TWO-WIRE CONTROL, EXTERNAL SOURCE

Remove the jumpers between terminals TB2-1 and 2 and between terminals TB2-4 and 5. Connect the switch between terminal TB2-3 and one side of the external source. Connect the other side of the external source to terminal TB2-4.

3.4.5 REMOTE INTERLOCK

Remove the jumper between terminals TB2-4 and 5. Any number of interlock contacts may be connected in series with these terminals to inhibit operation of power relay K1. These contacts may be associated with access doors, cooling systems, power sequencing relays, etc.

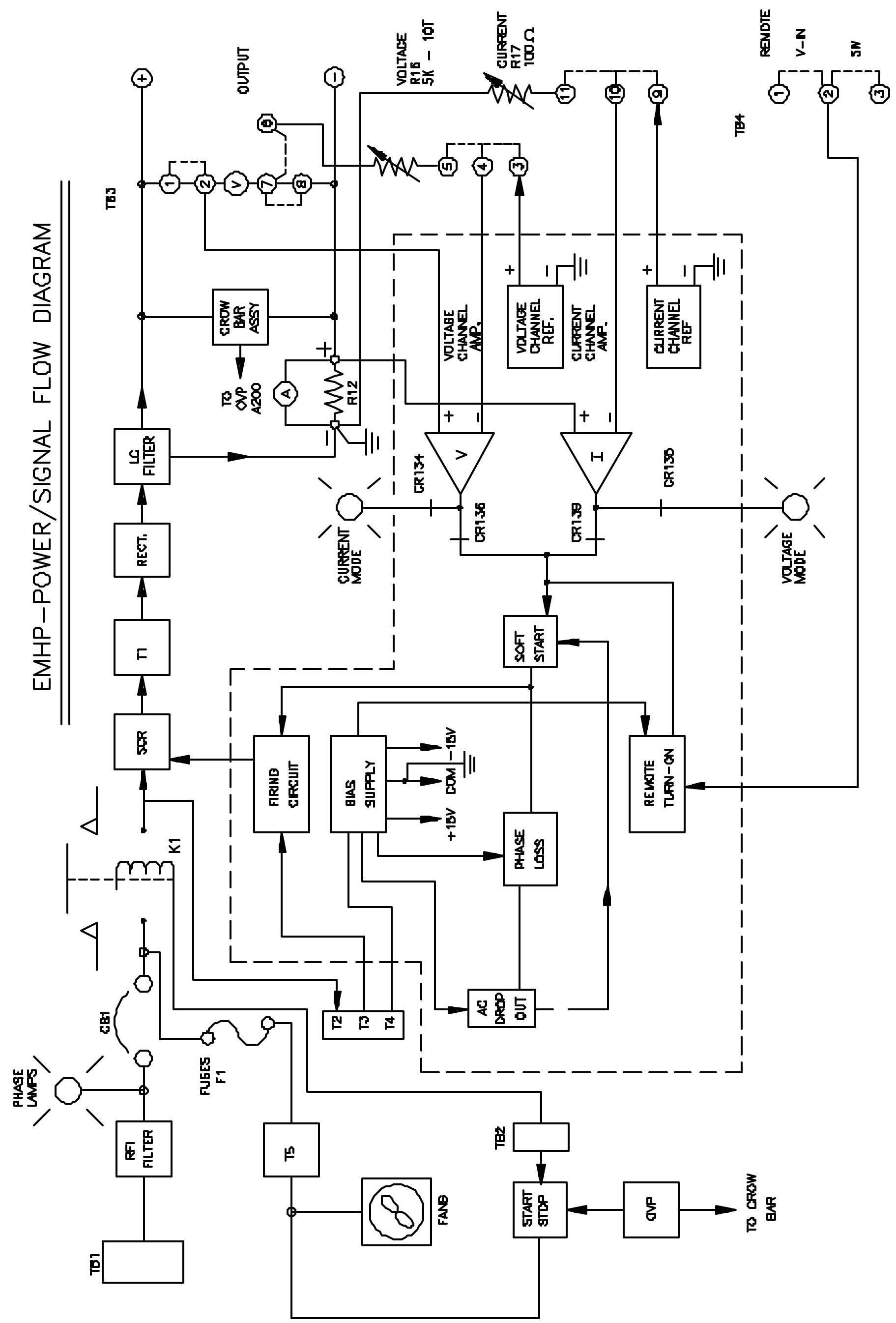
3.5 OVERVOLTAGE PROTECTION OPTION

3.5.1 ADJUSTMENT PROCEDURE

1. Set the VOLTAGE control fully counterclockwise, and the CURRENT and OV ADJ controls fully clockwise. Turn the power switch to the "ON" position and press the START button.
2. Set the output voltage to the desired tripping point with the VOLTAGE control.
3. Turn the OV ADJ control slowly counterclockwise until the OVP trips. This is indicated by both mode indicator lights being extinguished and the main contactor disengaging.
4. Set the VOLTAGE control fully counterclockwise.
5. Wait 2 minutes.
6. Press the START button and increase the output voltage slowly with the VOLTAGE control to verify that the OVP trips at the correct voltage.

CAUTION

The OVP is intended to be used as a low duty-cycle device. Repeated tripping of the OVP in succession should be avoided. When setting the OVP trip voltage, wait at least 2 minutes between trippings to prevent damage to the OVP components.



EMHP-POWER/SIGNAL FLOW DIAGRAM
OUTPUT
VOLTAGE R16 5K - 10T
CURRENT R17 100 Ω
REMOTE
V-IN
SW
TB4
TB3
CROW BAR ASSY
TO OVP A200
R12
LC FILTER
RECT.
T1
SCR
K1
CB1
PHASE LAMPS
RFI FILTER
TB1
FUSES F1
T5
FANS
TB2
START STOP
OVP
TO CROW BAR
VOLTAGE CHANNEL AMP.
VOLTAGE CHANNEL REF.
CURRENT CHANNEL AMP.
CURRENT CHANNEL REF.
CR134
CR136
CR138
CR135
CURRENT MODE
VOLTAGE MODE
SOFT START
FIRING CIRCUIT
BIAS SUPPLY
-15V
COM
+15V
PHASE LOSS
REMOTE TURN-ON
AC DROP OUT
T2
T3
T4

Figure 11

4 PRINCIPLES OF OPERATION

4.1 GENERAL

The EMHP power supply has a SCR module connected in each phase. These modules work in conjunction with the firing circuit and a feedback loop which is the constant voltage/constant current "ored" circuit. The feedback loop determines the firing angle of the SCRs, ensuring a regulated AC input voltage is applied to the primary of the power transformer. This regulated AC voltage is then adjusted to the proper level by the power transformer. After being full-wave rectified and filtered a constant output voltage or current is produced.

4.2 THE POWER FLOW

This section discusses the basic theory of power and signal flow of the EMHP three phase power supply. If used as a supplement to the maintenance data provided in Section V, it will aid in isolation of unit faults. Refer to Figure 11, block diagram of power and signal flow plus schematics #01-459-110 and #01-142-000 when reading this section.

Explanation of power flow is as follows: Upon applying power the AC passes through the RFI filter, circuit breaker CB1, K1 of the SCR networks.

The SCR modules contain two SCRs per module, which are connected in reverse parallel. Each SCR conducts upon the simultaneous application of a negative voltage to its cathode (input AC) and a positive voltage to its gate lead. During the positive half cycle Q2, Q4 and Q6 is conducting and during the negative half cycle Q1, Q3 and Q5 will conduct. The gate signal must be from 1-3 volts for the SCR to fire.

The firing angle of the SCR determines the amount of AC power applied to the input transformer. Thus the amplitude of the DC output of a SCR that is fired at an early point of the input cycle provides a higher output than one that is fired later in the input cycle.

The SCRs operating in conjunction with the firing circuits, controls the amount of AC power applied to the primary of power transformer T1. This transformer converts the input AC voltage to the appropriate AC level for the load voltage and current. The voltage is converted to DC by rectifiers on secondary side of T1. At a high continuous load current, L1 averages the DC voltage waveform at the input of the filter. At low load currents, the inductance is ineffective and capacitor C22 changes to peak pulse amplitude for necessary filtering. The phase delay of the input waveform ranges for approximately 60 degrees at the full rated output to nearly 180 degrees at low output voltage and current.

Resistor R10 acts as a pre-load to assure stability when the load is disconnected from the power supply.

The bias transformers T2 have two secondary windings. Terminals 4 and 6 on each transformer produces 50V RMS with respect to the center tap, terminal 5. This provides two sine wave signals spaced 180 degrees out of phase for referencing the SCR firing circuit to the line frequency. A voltage of 20V RMS is produced between terminals 7 and 8 of each transformer. Their voltages are full wave rectified on the A100 Control Board to provide + and -15V DC for control circuitry.

4.3 SIGNAL FLOW

All the controlling circuitry for regulation of this supply is located on the A100 Control Board schematic #01-142-000. Explanation of signal flow is as follows:

The 18-20 volts AC from bias transformer T2 provides a three-phase input to the bias section of the A100 control board. These inputs are used for different facets of the controlling process of the power supply. Most of the circuitry use the + and -15 volts DC regulated by IC101 and IC102. IC101 produces a plus 15V DC with a 150 milliampere load and IC102 a minus 15VDC with a 30 milliampere load. The unregulated DC voltage is used for voltage with the remote turn-on when dry contact control is used.

When one of the input phases drops out, the conduction cycle of Q108 is reduced, allowing capacitor C129 to start charging. After three cycles of line frequency, C129 charges sufficiently to cause Q109 to conduct which effectively grounds the drive circuit preventing the generation of further SCR gate pulses which shuts down the output of the unit.

The AC dropout circuit prevents the power supply from operating when the AC input drops below operating range. This circuit works as follows: C128 will start discharging through R149. This will cause Q107 to start conducting grounding the firing line to the SCRs and resets the "soft start" circuit.

Once input power is at the operating level, the "soft start" circuit will reset in the following manner: Capacitor C134 slowly starts charging through the base of Q110. As C134 charges, the base current will decrease allowing the collector voltage of Q110 to slowly rise which gradually increases the conduction angle of the SCR's.

Separate constant current references are provided for the voltage and current channels. The collector current of Q111 drives the voltage channel and Q112 the current channel. These current sources are referenced by the voltage across CR133, a temperature-compensated zener diode. Since the voltage difference across the summing junction of IC104 pins 1 and 2 is essentially zero, the voltage across CR133 also appears across the series combination of R167 and R168 (also R171 and R173 since the Vbe of Q111 and Q112 is essentially constant current). A constant voltage across a fixed resistance produces a constant collector current. The current from each of these sources is adjustable to 1 mA by R167 and R171.

The reference current level for the voltage channel flows from J107-2 to TB3-3. With jumpers between terminals TB3-3, 4 and 5, the voltage level produced when this current flows through the VOLTAGE control R13 is applied to pin 8 of IC104. The signal on the other input of IC104 pin 9 is derived from the power supply output voltage level through voltage divider R177 plus R178 and R179. Maximum rated output voltage produces +5Vdc at pin 9 of IC104. With R13 in the fully clockwise position, +5Vdc is applied to pin 8 of IC104. If attenuated output voltage changes from the value set by R13 (because of load changes, for example) an error signal will be developed at the output of IC104, pin 10. This error signal, via the SCR control circuitry, will cause a proportional change in the output voltage so as to bring the voltage on pin 9 of IC104 equal to that applied to pin 8.

The action of the current channel is identical to that of the voltage channel with the exception that the controlled quantity is being sampled across the shunt R12. This sampled voltage is compared to the reference voltage produced at pin 6 of IC104, which is established from the front panel current control R14. (0 to 100 millivolts DC).The output of the voltage channel amplifier and the current channel amplifier are "ored" together by diodes CR136 and CR139. Whichever channel has a higher positive output signal overrides the effect of the other and becomes the channel controlling the DC output. The output of either the voltage or current channel is fed to the base of transistor Q110 which operates as a linear amplifier whose output is fed to the phase control circuit Q101-106.

The mode indicator lights are controlled by the outputs of the voltage and current channels. For example, if the voltage channel is in control, output of the current channel is negative. This will cause current to flow through CR135 lighting the voltage LED. When the current channel is in control, current will flow through CR134 lighting the current LED.

The voltage signal developed across R164 is a source of feedback fed through R187 and C145, and R182 and C142, to stabilize the current and voltage channels respectively. Additional loop compensation is provided by R183 and C143, and R185 and C144.

A control signal that momentarily switches negative at the base of Q110 allows the collector voltage to increase the firing line voltage thus increasing the SCR firing angle. A positive-going signal at the cathodes of CR136 and CR139 causes the output of the power supply to reduce by retarding the conduction of the SCR's. The amplitude of the phase angle is directly proportional to the polarity of the base signal of Q110. The collector voltage of Q110 is approximately 7 to 8 volts at full conduction angle and 5 to 6 volts for minimum conduction angle.

4.4 SCR FIRING CIRCUIT

The SCR firing pulses are developed by properly timed conduction of Q1 through Q6. this is accomplished by the combination of the phase related AC signals from terminals 4, 5 and 6 of T2, and the variable level from Q10.

Examining the typical firing circuit for one SCR only, R101 and CR101 produce a 12V square wave at line frequency with axis crossings at 0°C and 180°C. R107 and C102 integrate the square wave into rising and falling ramp voltages with transition in voltage direction occurring just past

0°C and 180°C due to the phase shifting effect of the RC network. When a positive DC level from Q110 via J7-15 is superimposed on the ramp voltage across C102, Q101 will be driven into conduction at some time during the positive-going position of the ramp. This conduction causes a sudden current flow in the primary of T101 and a resultant pulse of trigger current from the secondary winding of T101 to the gate of SCR Q1. Operation of the opposite firing circuit is identical except for 180 degrees displacement of the gate pulse which fires Q2 when its anode is positive.

C109 through C114 store the SCR gate pulse energy, and C108 and R128 serve as a filter to prevent pulse loading of the +15V supply. Resistors designated "*3" on the A100 schematic are selected at test to equalize SCR firing angles.

Thermal switch TS1 is connected across C134. If the diode heatsink temperature rises excessively, the thermal switch closes causing Q110 to be driven into saturation, thus shutting down the power supply output. The thermal switch will reset automatically when the heatsink temperature drops sufficiently.

4.5 REMOTE TURN-ON

Remote Turn-On allows the user to turn the supply on from a remote location with 12-24VDC or 24-115VAC or a dry contact closure. IC103 isolates the remote turn-on circuitry from the power supply common.

Transistor Q110 is held in saturation by the 15 volts of the bias supply through R157 and CR130. When the internal LED of IC103 is activated by power at pins 1 and 2, the internal darlington transistor causes most of the 15 volts to be shunted to ground. This allows Q110 to start amplifying.

When a n/o voltage switch (dry contact) for remote turn-on is used, Q113, L101 and CR129 supply the control signal for the optical isolator. Q113 is connected across the unregulated 20 DC volts of the bias supply and is used as a relaxation oscillator.

Each time Q113 conducts, it discharges C147 through L101 inducing a voltage in its secondary winding. This voltage is rectified by CR129 and filtered by C149. When a switch is connected between J12-3 and J12-2 the voltage will make a complete loop to operate the optical isolator.

4.6 OVERVOLTAGE PROTECTION OPTION A200

On units so equipped, the OVP option protects the power supply and the load from excessive output voltage caused by a failure in the control circuitry of the power supply, or a defect or misadjustment in any remote control circuit.

IC201, pin 2 samples the power supply output voltage level through R202, R203 and R204 divider. Power for IC201 is connected through R201 and CR201 to pin 1. IC201 has a set reference built into the Chip. Output from pin 3 is fed back into pin 4. C204 filters this signal. Pin 8 of IC201 is the output which goes positive and turns on Q201 and Q202. Q201 provides a return path to GND for P1 of the A100 PC Board or firing control terminal 5 of T2 transformers which halts SCR firing. At the same time Q202 conducts and activates the OVP relay K201 interrupting the power to the main contactor coil through the normally closed contacts 1 and 7 of K201. The OVP supplies a signal to Q204 SCR which crow bars the output.

5 MAINTENANCE

NOTE: Please refer to the Warranty at the front of this manual before proceeding with servicing or repair of this unit.

WARNING
Lethal voltages are present in this power supply. Extreme caution must be observed whenever any cover or panel is removed, even on units equipped with interlock switches.

To avoid serious damage, all test equipment must be suitably isolated from the power line and from earth ground when making measurements on the primary side of the power supply (including the output portions of the SCR gates). Since test equipment cabinets may be "floating" at several hundred volts above ground potential, severe shock hazards exist.

NOTE: Maintenance and or calibration procedures contained in this section will not void the unit warranty.

5.1 GENERAL

5.1.1 AIR INTAKE FILTER

The plastic mesh air intake filters should be inspected at intervals determined by operating and environmental conditions. For access to the filter, remove the filter holder frame and remove the filter.

CAUTION: Disconnect all power before removing any panels. The filter material may be washed with detergent, not solvent. Material which has deteriorated or cannot be adequately cleaned should be replaced.

5.1.2 ACCESS TO EQUIPMENT

The input RFI filter, all printed circuit boards and all adjustment controls are accessible by removing the side and top covers. The main rectifier diodes can be removed as follows: Remove the adjacent panel. Unplug fan thermal switch leads. Disconnect main diode and heat sink connections. Remove small heat sink retainers and slide heat sink assembly from its mounting rails. The SCRs can be removed as follows: Remove the adjacent panel. Unplug gate leads. Disconnect main connections. On Size II and III units, remove small heat sink retainers and slide heat sink assembly from its mounting rails.

NOTE: A thermally-conducting grease is used between the diodes and SCRs and their heat sinks. Before reassembling any of these parts, be sure that the mating surfaces are clean and have a thin coating of Dow Corning #5 compound or equivalent.

5.1.3 PARTS REPLACEMENT

In general, replacement parts are completely defined by the value and tolerances indicated on the schematics. However, certain values are selected at the factory.

If any of these components require replacement, the value of the component in the unit should be used rather than the normal value to within 1% relative to each other. The same applies to CR101 through CR106.

5.1.4 EQUIPMENT REQUIRED FOR CALIBRATION OR MAINTENANCE

1. Oscilloscope - dual trace - 20kHz bandwidth - isolated from ground (Tektronix 2213 with 10x voltage probe).
2. RMS Multimeter - 100 volts DC - 1000 volts AC (Hewlett Packard HP-3465A).
3. VOM (Simpson 260)
4. Load - equal to the output capability of unit.

5.2 CALIBRATION

This procedure applies to the adjustment and calibration of a properly functioning unit only. Any malfunctions must be corrected before proceeding with calibration. It is only necessary to remove top cover to make these calibrations. (see Sections 5.2 through 5.2.4)

5.2.1 NULL ADJUSTMENTS

1. Connect a load and an oscilloscope across the output terminals.
2. Turn the VOLTAGE control completely clockwise and the CURRENT control completely counterclockwise.
3. Turn the power on.
4. Turn the I NULL control R184 in one direction until ripple appears on the oscilloscope, then turn R184 back slowly until the ripples disappear.

5.2.2 CURRENT SOURCE ADJUSTMENTS

1. Connect the reference voltmeter across the output terminals. The output may be loaded or unloaded as desired.
2. Turn the VOLTAGE and CURRENT controls completely clockwise.
3. Turn the power supply on.
4. Adjust the V CAL control R167 until the reference voltmeter indicates the full rated output voltage of the power supply, or just slightly above. The front panel voltmeter reading should agree ±2% within its full scale range. If it does not, check its zero adjustment or replace it.
5. Turn the power supply off and adjust the reference ammeter (with shunt as applicable) in series with a load or short circuit across the output terminals.
6. Turn the power supply on.
7. Adjust the I CAL control R171 until the reference ammeter indicates the full rated output current of the power supply plus 1%.

5.2.3 AMMETER CALIBRATION

1. Connect the reference ammeter (with shunt as applicable) in series with a load or short circuit across the output terminals.
2. Turn the VOLTAGE control fully clockwise.
3. Check the zero adjustment of the front panel ammeter.
4. Turn the power supply on.
5. Adjust the CURRENT control so that the reference ammeter indicates full rated output current of the power supply.
6. Adjust R11 (located just behind the front panel) until the front panel ammeter reading equals that of the reference ammeter.

5.2.4 FIRING BALANCE

1. Connect a load to the unit.
2. Connect oscilloscope probe (x10) on TB3-1 and ground on TB3-8.
3. Adjust R120, R123, R126 for even peak voltages from cycle to cycle of the DC output.

5.3 TROUBLESHOOTING

The power supply is divided into two basic circuit areas, power flow and signal control. The power flow circuitry consists of circuit breaker, SCRs, power transformer, rectifiers, choke and capacitors as well as the cabling interconnecting them. The signal control circuitry is contained on the removable printed circuit card. Most unit malfunctions will originate on the circuit card. Reviewing the Principles of Operation is recommended before starting to troubleshoot the supply.

WARNING:
When servicing supply dangerous voltage levels exist. Be especially careful of personnel and equipment when measuring primary circuitry since this is at line potential.

5.3.1 OVERALL TROUBLESHOOTING PROCEDURE

1. Check for obvious troubles such as input power failure, loose or incorrect strapping on rear terminals or defective meter.
2. It is common for the trouble to be caused by the DC bias or reference voltages, thus it is a good practice to check voltages on the A100 control board before proceeding to the next step. The A100 board may be disconnected from the SCRs by pulling plugs J1-J6.

Some voltages to check are:

IC104 - pin 11	+15 volts
IC104 - pin 7	-15 volts
IC103 - pin 5	2-3 volts
Q110 - Collector	3-8 volts*

*This voltage is clamped at 10 volts by CR132.

3. Disconnect load and proceed to the next paragraph.
4. Troubleshooting is more effective if the unit is operated in the normal mode (Normal Programming Section 3.3.1).
5. Before turning on the supply turn both CURRENT and VOLTAGE channel controls completely off (counterclockwise).

Where only one terminal is specified, measurements are made with respect to I shunt common or a negative output terminal.

The chart that follows is a troubleshooting guide that should aid in discovering operational problems in the supply.

5.3.2 TROUBLESHOOTING CHART

START	PROBLEM
TURN SUPPLY ON	OUTPUT GOES HIGH - FULL SCALE OR ABOVE. IF UNIT CONTAINS OVP OPTION - K1 TRIPS

1. TURN SET OFF 2. DISCONNECT A100 BOARD FROM SCRs BY PULLING PLUGS J1-J6 3. TURN SET ON

<table>
<tr><th>PROBLEM</th><th>REMEDY</th></tr>
<tr><td>SET STILL OUT OF CONTROL</td><td>SHORTED SCR</td></tr>
<tr><td rowspan="2">SET NO LONGER OUT OF CONTROL</td><td>CHECK R13 AND R14 - COULD BE OPEN</td></tr>
<tr><td>CHECK R13
1. Connect digital-meter to J7-2 and common.
2. As R13 is rotated through its ranges, the voltage across it will vary from zero to 3 to 5 volts.</td></tr>
<tr><td rowspan="2">SET NO LONGER OUT OF CONTROL</td><td>CHECK R14
1. Connect digital-meter to J7-9 and common. (Terminal 12 on TB3)
2. As R14 is rotated through its range the voltage across it will vary from 0-100mv</td></tr>
<tr><td>Check transistor Q110 on the A100 control board, could be open.</td></tr>
</table>

UNIT ON BUT NO OUTPUT	Observe phase indicator lights. All LEDs must be lit Check AC input voltage. Check AC signal at J113-1, 3 and 4 on A100 Control Board. Check output of bias transformer T2 across pins 7 and 8. Open circuit voltage 20 volts. If there is not voltage at the bias transformers check, fuses F3-5.
	Check transistor Q110 on the A100 Control Board, could be shorted
	Check transistors Q107 and Q109 on the A100 control Board, could be shorted. Check transistor Q108 on the A100 Control Board, could be open.
TURN VOLTAGE AND CURRENT CHANNELS UP SLOWLY	CIRCUIT BREAKER SNAPS OFF
	Check output filtering capacitors C22 could be defective
EXCESSIVE RIPPLE	One of the main SCRs (Q1-Q6) could be open
	Inductor coils L1 A-B-C could be shorted.
EXCESSIVE RIPPLE	SCR control circuit on the A100 Control Board could be defective 1. Check for equal ramp amplitudes across R101-106. 2. Check that the wave forms across C109-114 drops rapidly to 1.4 volts.
UNIT IS OSCILLATING	Check C142 and C145, could be defective.
CURRENT OR VOLTAGE CHANNEL DOES NOT REGULATE	Check IC104 and Q110, could be defective.

5.4 OVERVOLTAGE TROUBLESHOOTING

Most overvoltage faults fall into two general categories:

1. The circuit overvoltage fires at all times even when the trip point is adjusted to maximum.

   Check SCRs Q201 and Q202. They could be shorted.

   IC201 could be defective.

2. The overvoltage is completely inoperative at any trip point setting.

   Check SCRs Q201 and Q202. They could be open.

   IC201 could be defective.

5.5 DIODE REPLACEMENT

1. Diodes are location on bottom of unit mounted to a heatsink.
2. After removing Heat Sink Assembly, remove diodes and wipe heat sink clean of all compound.
3. Put a fine coating of compound (low thermal contact resistance) on surface of each diode that meets heat sink. Be careful not to get any on threads of diode.
4. Mount diodes to heatsink with sheet metal ("PAL") nut. Torque chart follows: (PAL nuts are used on 3/4 - 16 threaded devices)

DIODE THREAD SIZE	TORQUE PRESSURE
1/4 - 28 threaded device	30 inch pound - max. torque
3/8 - 24 threaded device	120 inch pound - max. torque
1/2 - 20 threaded device	130 inch pound - max. torque
3/4 - 16 threaded device	30 foot pound - max. torque

5. Use new nut when a new diode is installed.